



Introduction to Image Processing Libraries (IPP)

Xuenan Cui, xncui@inha.ac.kr

Computer Vision Lab.

School of Information & Communication Engineering

Inha University

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IPP Introduction



❖ Integrated Performance Primitives

- Provide in Intel
- Low-level library
- Using MMX, SSE, SSE2,...
- Compared to OpenCV
 - IPP Functions are fast
 - But **only work on Intel Processors**
- IPL was the ancestor of IPP
 - IplImage type is no longer used

IPP Introduction



<https://software.intel.com/en-us/articles/intel-ipp-82-library-release-notes>

❖ Version information

- 2001.02 - IPP1.0
- ...
- 2008.02 - IPP 6.0 Beta
- 2008.08 - IPP 6.0
- 2009.03 - IPP 6.1
 - Serial Number:
 - G24R-D452RCVK
 - G24R-5LLC2TS3
- 2012 - IPP 7.1(support the AVX)
- 2014 - IPP 8.2(support the AVX)
- 2015 – IPP9.0(support the AVX2)
- IPP2018
- IPP2019
- IPP2020

IPP Introduction



❖ Documents information

- Signal processing (vol.1)
- Image processing (vol.2)
- Small matrices and realistic rendering (vol.3)
- Cryptography (vol.4)

IPP Introduction



❖ Integrated Performance Primitives

- Offers thousands of optimized functions for **signal, image, matrix processing, 3D data processing**
 - Signal(ipps)
 - Image(ippi)
 - Matrix(ippm)
 - 3D(ippr)

IPP Applications



Video coding	Data compression
Signal processing	Image color conversion
Audio coding	Cryptography/CAVP validated
Image processing	String processing/Regular expressions
Speech coding	Vector/ Matrix mathematics
JPEG coding	Ray-Tracing/Rendering
Speech recognition	Computer vision

IPP Installation & Setting



- ❖ <https://software.intel.com/content/www/us/en/develop/tools/oneapi/base-toolkit/download.html?operatingsystem=window&distributions=webdownload&options=offline>

Get the Intel® oneAPI Base Toolkit

Select options below to download

Operating System:
Windows

Distribution:
Web & Local (recommended)

Installer Type:
Local

Local Installer

- Includes all tools in the toolkit
- Recommended for host machines with poor or no internet connection

What's Included in the Intel® oneAPI Base Toolkit for Windows*

Download size: 3.3 GB
Install space required: 22.6 GB

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Installation Instructions for Windows*

- Step 1:** Select the .exe file to launch the GUI installer.
- Step 2:** Follow the instructions in the installer.
- Step 3:** Explore the [Get Started Guide](#).

IPP Installation & Setting



❖ Install and setting

- Download the IPP software from <http://downloadcenter.intel.com/>
- Visual studio 6.0 [Tools → Option → Directories]
 - Include files
 - IPP\6.0\ia32\include
 - Library files
 - IPP\6.0\ia32\lib
 - IPP\6.0\ia32\stublib

IPP Installation & Setting



❖ Install and setting

- Visual studio 2005 [Tools → Option → Projects → VC++ Directories]
 - Include files
 - IPP\6.0\ia32\include
 - Library files
 - IPP\6.0\ia32\lib
 - IPP\6.0\ia32\stublib

IPP Installation & Setting



- ❖ Copy dll files to the current folder or windows\system32 folder
 - C:\Program Files\Intel\IPP\6.0\ia32\bin
 - Project → properties → Linker → Input
 - ippcore.lib ipps.lib ippi.lib ippcv.lib ippsc.lib



❖ Set the Windows Environmental Variable for KMP_DUPLICATE_LIB_OK to TRUE.

❖ Windows Vista

- Choose Start > Control Panel.
- Click System and Maintenance, click System , and then click Advanced Settings in the left pane.
- Click Environmental Variables at the bottom of the dialog box.
- In the User Variables section, click New.
- Enter the variable name KMP_DUPLICATE_LIB_OK (name must contain capital letters and underscores).
- Enter the variable value TRUE and click OK.
- In the System Variables section, click New..
- Enter the variable name KMP_DUPLICATE_LIB_OK.
- Enter the variable value TRUE and click OK.
- Click OK to close Environmental Variables, and click OK again to close System Properties.

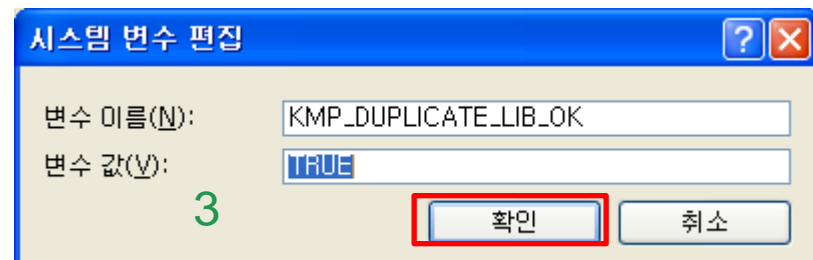
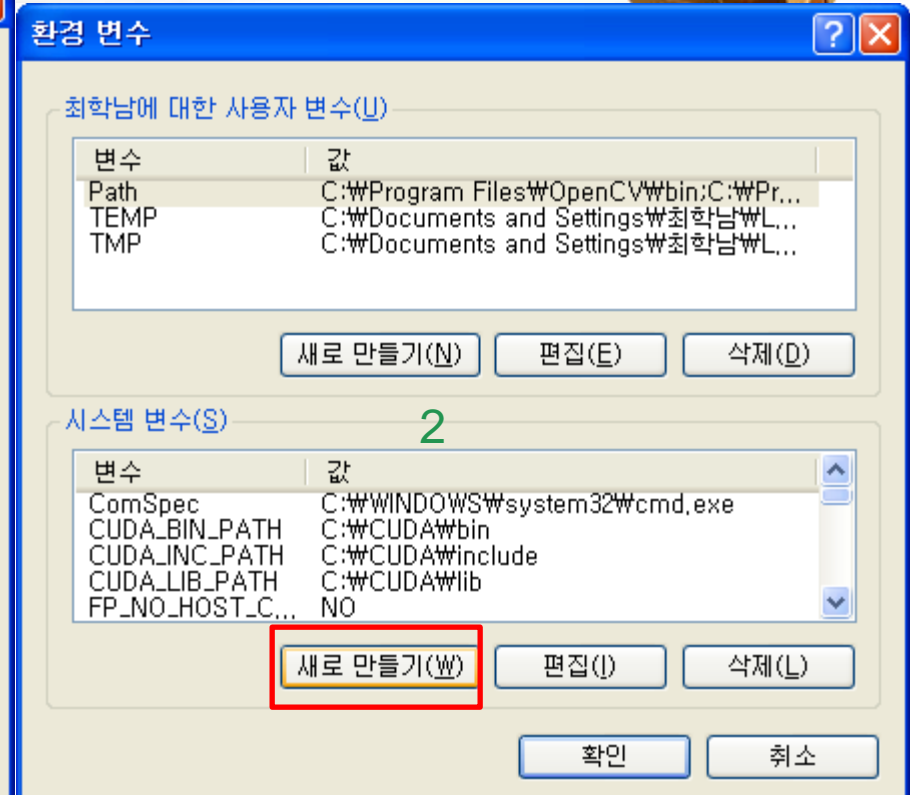
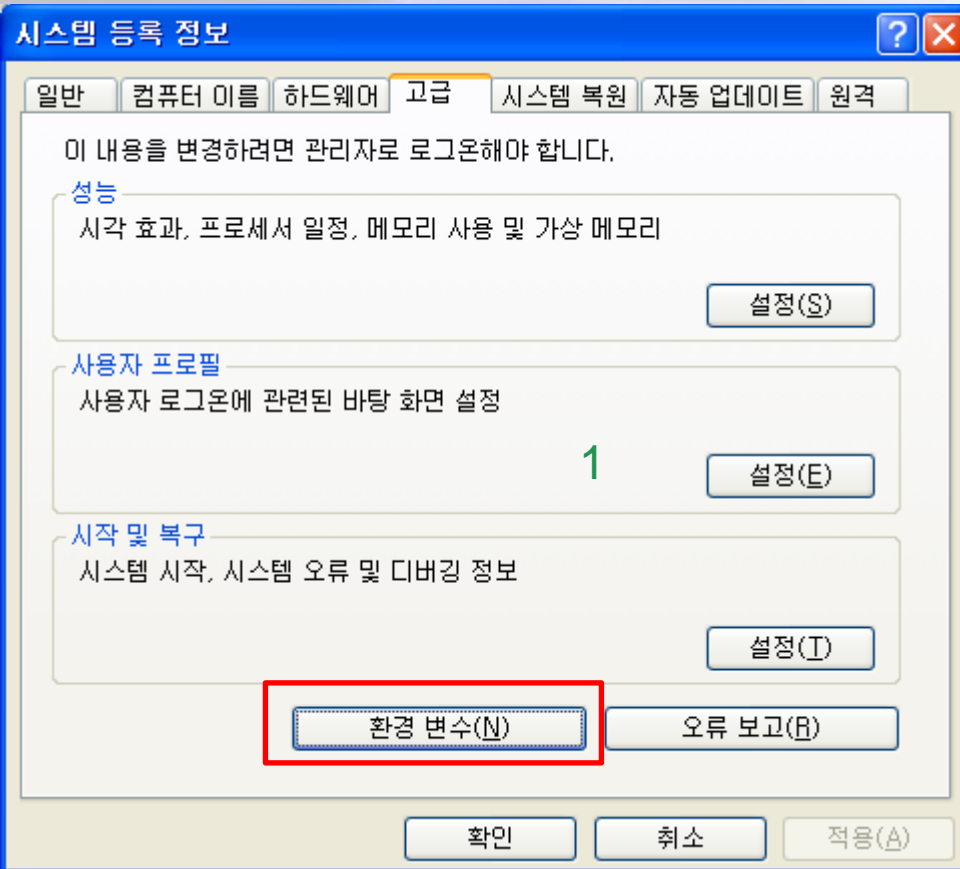


❖ Set the Windows Environmental Variable for KMP_DUPLICATE_LIB_OK to TRUE.

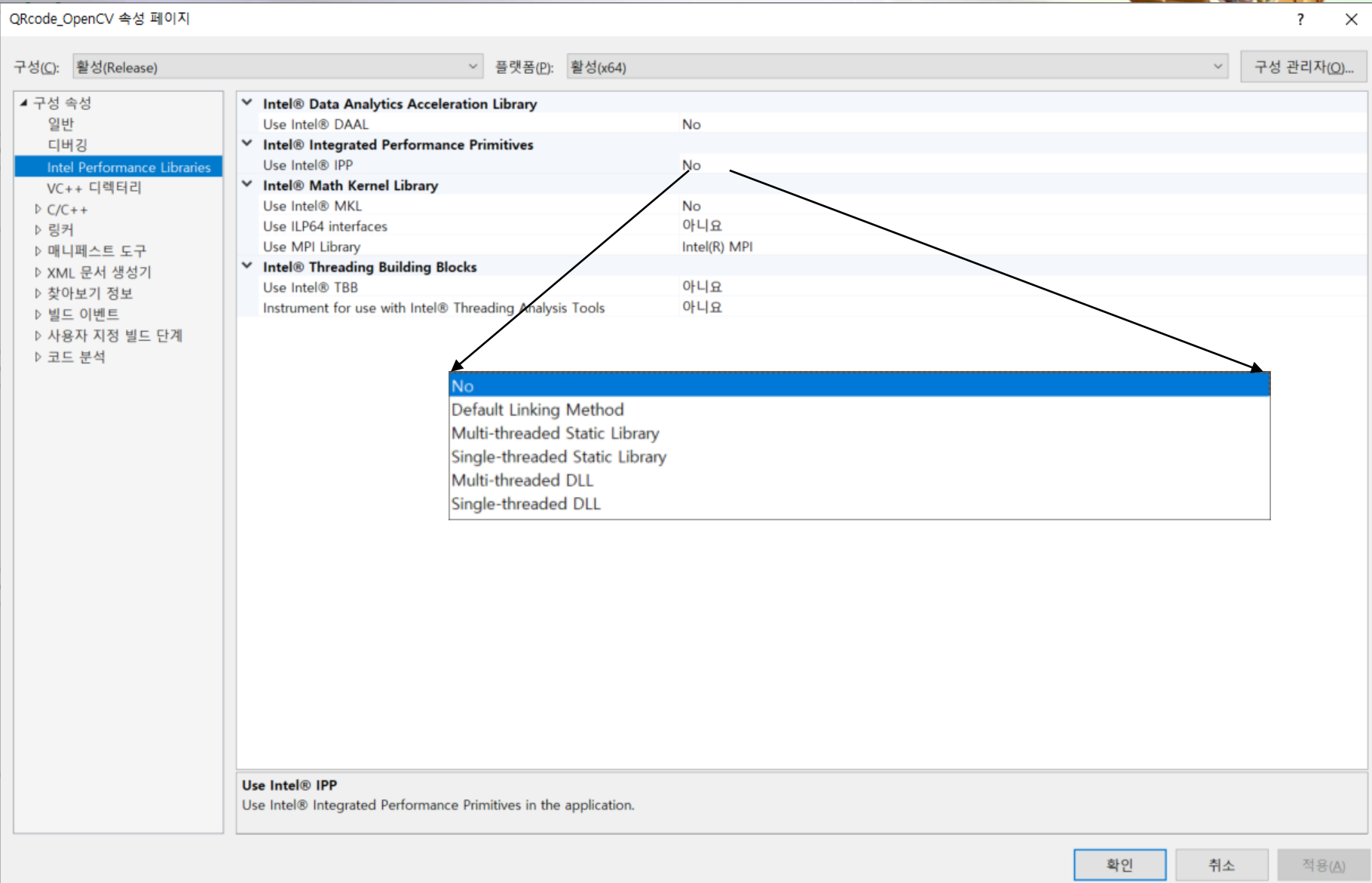
❖ Windows XP

- Choose Start > Control Panel, and then double-click System.
- Select the Advanced tab in the System Properties window.
- Click Environmental Variables at the bottom of the dialog box.
- In the User Variables section, click New.
- Enter the variable name KMP_DUPLICATE_LIB_OK (name must contain capital letters and underscores).
- Enter the variable value TRUE and click OK.
- In the System Variables section, click New.
- Enter the variable name KMP_DUPLICATE_LIB_OK.
- Enter the variable value TRUE and click OK.
- Click OK to close Environmental Variables, and click OK again to close System Properties.

Set the Environmental Variable



Environmental



IPP Data types



Code	IPP Type	Usual C Definition
8u	Ipp8u	unsigned char
8s	Ipp8s	char
16u	Ipp16u	unsigned short
16s	Ipp16s	short
32u	Ipp32u	unsigned int
32s	Ipp32s	int
32f	Ipp32f	float
64f	Ipp64f	double
16sc	Ipp16sc	struct { Ipp16s re; Ipp16s im; } Ipp16sc;
32sc	Ipp32sc	struct { Ipp32s re; Ipp32s im; } Ipp32sc;
32fc	Ipp32fc	struct { Ipp32f re; Ipp32f im; } Ipp32fc;
64fc	Ipp64fc	struct { Ipp64f re; Ipp64f im; } Ipp64fc;

Image Data types and Ranges



Data Type	Lower Bound		Upper Bound	
	Identifier	Value	Identifier	Value
8s	IPP_MIN_8S	-128	IPP_MAX_8S	127
8u		0	IPP_MAX_8U	255
16s	IPP_MIN_16S	-32768	IPP_MAX_16S	32767
16u		0	IPP_MAX_16U	65535
32s	IPP_MIN_32S	-2^{31}	IPP_MAX_32S	$2^{31} - 1$
32u		0	IPP_MAX_32U	$2^{32} - 1$
32f [†]	IPP_MINABS_32F	$1.175494351e^{-3}$	IPP_MAXABS_32F	$3.402823466e^{38}$

[†] The range for absolute values

Descriptors



Code	Description
A	Data contains an alpha channel as the last channel, requires C4, not processed
A0	Data contains an alpha channel as the first channel, requires C4, not processed
Cn	Data is made up of n discrete interleaved channels(1,2,3,4)
D2	Image is two-dimensional
I	In-place
M	Uses mask ROI for source and destination image
Pn	Data is made up of n discrete planar channels, with a separate pointer to each plane
R	Uses region of interest (ROI)
Sfs	Saturation and fixed scaling mode is used

Function prototypes



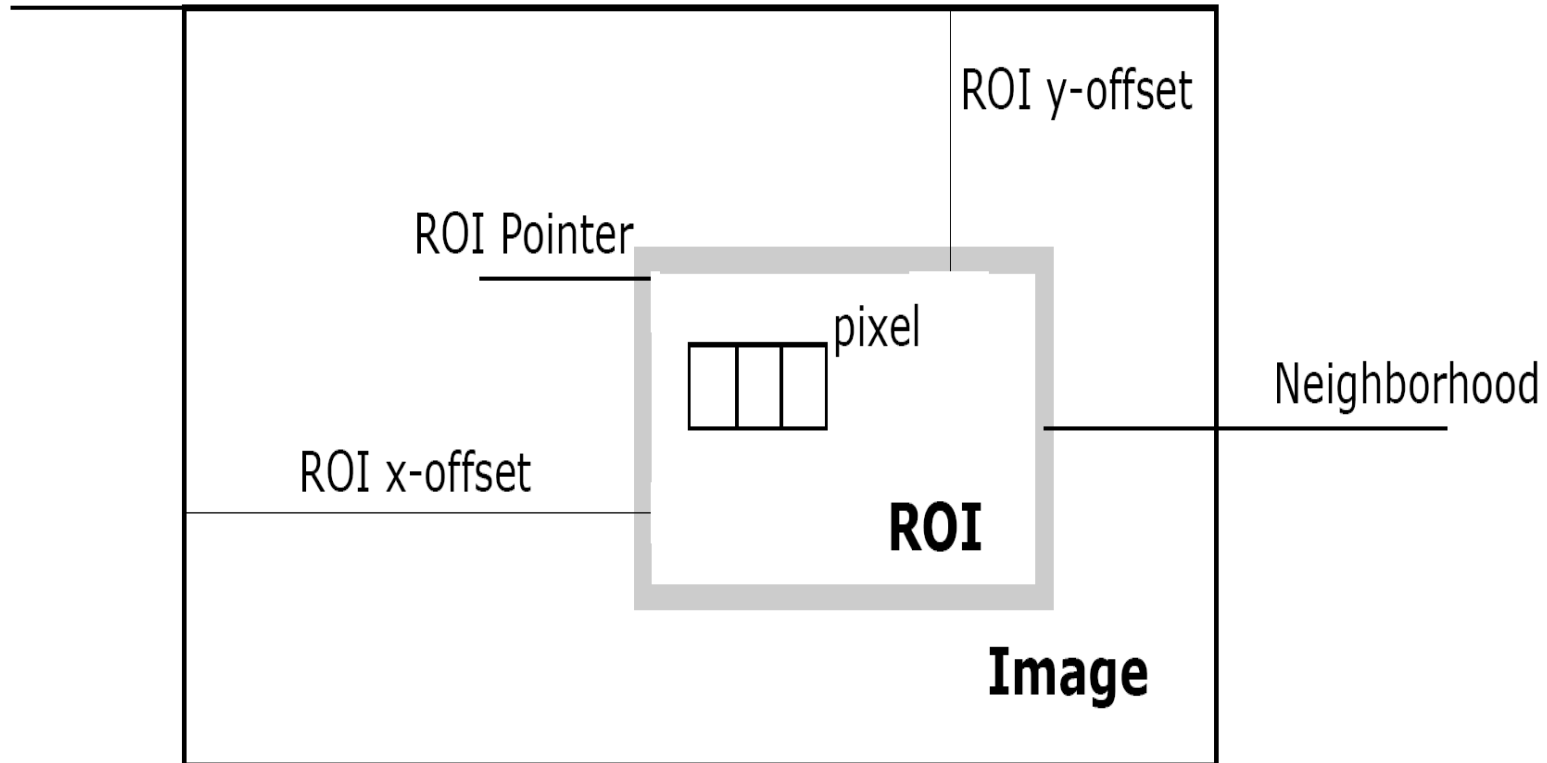
❖ Function prototypes

- `ipp<data-domain><name>_<datatype>[_descriptor]`
(`<parameters>`)
 - `ippiColorToGray_32f_C1R(...)`
 - `ippiFilterMedian_8u_C3R(...)`

ROI in IPP



Image Pointer



ROI in IPP



❖ ROI is specified by

- roiSize parameter of the **IppiSize** type
- pSrc and pDst pointers to the **starts of** source and destination ROI buffers
- srcStep and dstStep parameters which are equal to distances in **bytes** between the starts of consecutive lines in source and destination images, respectively.

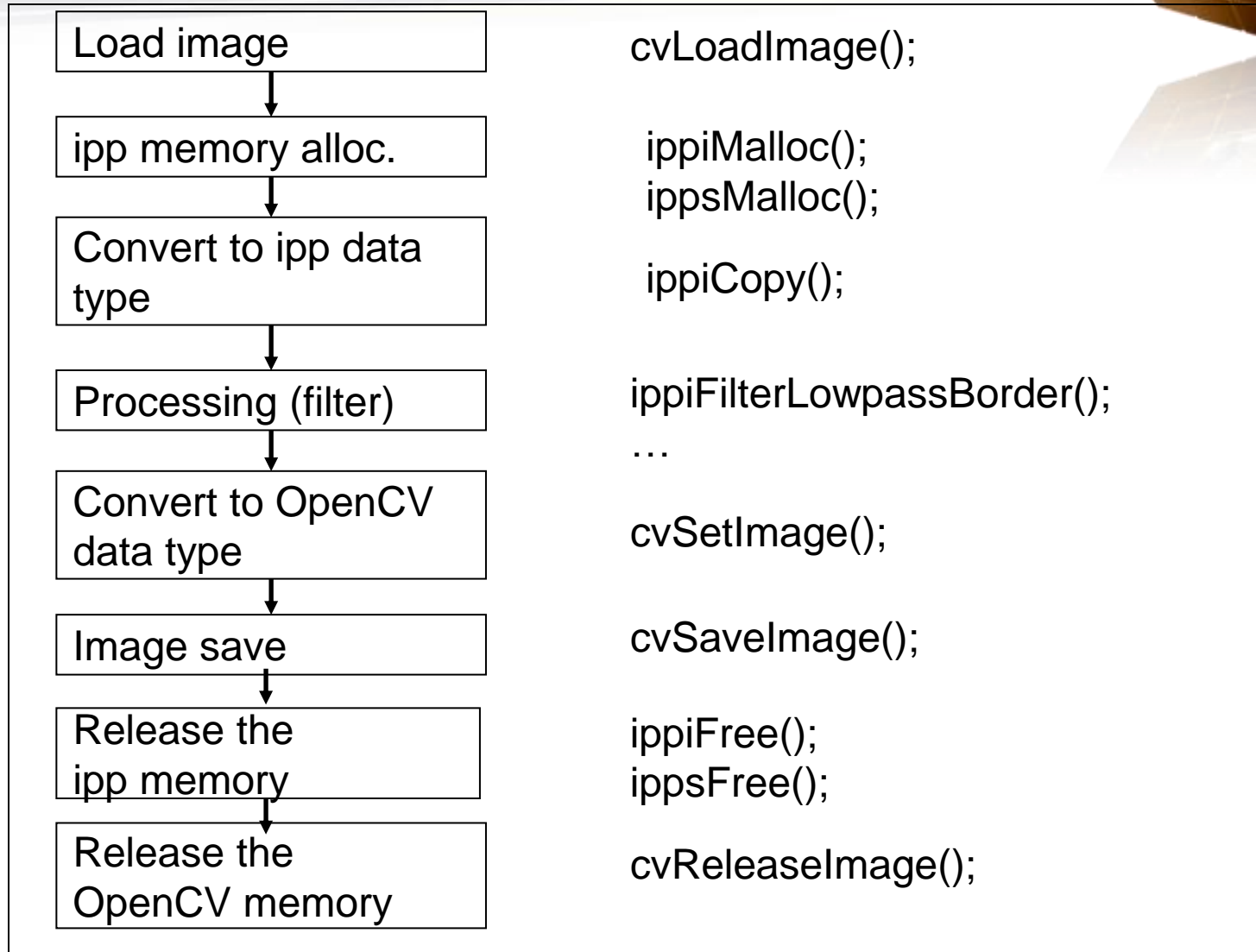
Basic image processing functions

<https://software.intel.com/content/www/us/en/develop/documentation/ipp-dev-reference/top.html>



Image processing algorithms	Ipp functions
Mean	ippiFilterLowpass_8u_C1R
Median	ippiFilterMedian_8u_C1R
Erosion	ippiErode3x3_8u_C1R
Dilation	ippiDilate3x3_8u_C1R
Opening	ippiMorphOpenBorder_8u_C1R
Closing	IppiMorphCloseBorder_8u_C1R
And	ippiAnd_8u_C1R
Or	ippiOr_8u_C1R
Xor	ippiXor_8u_C1R
Sobel horizontal	ippiFilterSobelHoriz_8u_C1R
Sobel vertical	ippiFilterSobelVert_8u_C1R

How to combine OpenCV and IPP



```

#include<ipp.h>
#include"opencv2/opencv.hpp"
using namespace cv;
// Sobel filter
int main() {
Mat image = imread("Knee.bmp", 0);
if (image.empty())return 0;

IppiSize size, tsize;
size.width = image.cols;
size.height = image.rows;
Ipp8u *S_img = (Ipp8u *)ippsMalloc_8u(size.width*size.height);
//Ipp8u *D_img = (Ipp8u *)ippsMalloc_8u((size.width - 1)*(size.height - 1));
Ipp8u *T_img = (Ipp8u *)ippsMalloc_8u(size.width*size.height);
Ipp16s *T = (Ipp16s *)ippsMalloc_16s(size.width*size.height);

ippiCopy_8u_C1R((const Ipp8u*)image.data, size.width, S_img, size.width, size);
tsize.width = image.cols;
tsize.height = image.rows;
ippiFilterSobelHorizBorder_8u16s_C1R(S_img, size.width, T, size.width , tsize, ippMskSize3x3, ippBorderConst,
255, T_img);
//ippBorderConst ippBorderRep1
Size s;
s.width = image.cols;
s.height = image.rows;
cv::Mat dst(s, CV_16S, T);

imshow("image", image);
imshow("dst", dst);
waitKey(0);

return 0;
}

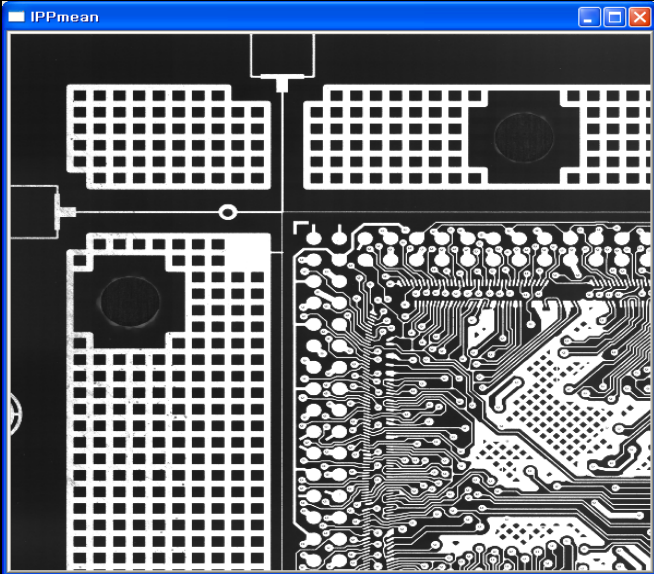
```

some bugs

IPP Sample Programming



```
C:\WINDOWS\system32\cmd.exe
OpenCV Processing time: 74.572615 msec
IPP Processing time: 27.598738 msec
ippcore-6.0.dll 6.0 Update 1 build 167.32
```



HW #2



1. Implement the Gaussian function 5x5 filter using IPP.
 2. Implement the median 5x5 filter using IPP.
 3. Test on different size of images such as 256x256, 512x512, 1024x1024, 2048x2048
 - Apply the resize function to create different size of images.
-
- ❖ compare the **results image** and **processing time** between opencv and ipp.
 - *Check the result images same or not.*
 - *If the results are different, explain why they are different.*
 - ❖ Submit to the E-class
 - ❖ Due date: refer the blackboard

Reference



- [1] Gary bradski, Adrian Kaebler, “Computer Vision with the OpenCV Library,” 2008
- [2] www.opencv.co.kr
- [3] “Intel Integrated Performance Primitives for Intel Architecture” Reference Manual, 2007.01
- [4] J.Landre, “Programming with Intel IPP and OpenCV under GNU Linux”, 2003.07
- [5] Stewart Taylor, “How to Optimize Software Applications Using Intel IPP”,
- [6] <http://www.intel.com>